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(54) Foot Prosthesis

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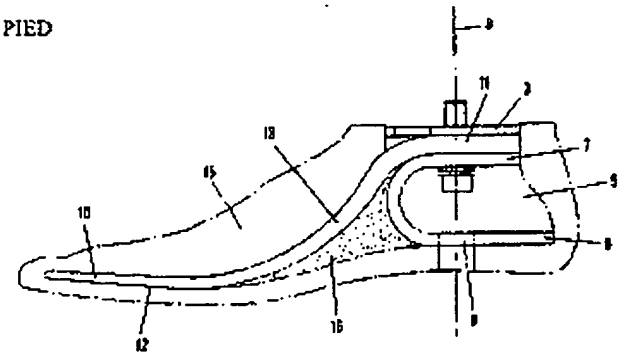

(57) Abstract

A foot prosthesis comprising a front plate (1) and a heel (2). The heel (2) is C-shaped with the opening (5) of the C facing the back of the prosthesis. The front plate has a stretched S shape and comprises a forward portion (10), a rear portion (11) and a middle portion (13) where the curvature changes direction. The front plate and the heel each comprise a plurality of layers of carbon, glass or aramide fibres. The fibre layers of the front plate and those of the heel are respectively coated with one or more layers of woven material then impregnated and shaped.

(57) Abrégé

La prothèse de pied comporte une spatule (1) et un talon (2). Le talon (2) est en forme de "C", l'ouverture (5) du "C" étant dirigée vers l'arrière de la prothèse. La spatule est en forme de "S" étiré. Elle comporte une partie avant (10), une partie arrière (11) et une partie intermédiaire (13) présentant une zone d'inflexion de la courbure. La spatule et le talon comportent chacun une pluralité de couches de fibres de carbone, de verre ou d'aramide. L'ensemble des couches de fibres de la spatule et l'ensemble des couches de fibres du talon sont respectivement recouverts d'une ou plusieurs couches en matériau tissé puis sont imprégnés et mis en forme.

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Foot prosthesis

Technical Field

This invention concerns a foot prosthesis made from a composite material.

Background Art

Various foot prostheses have already been proposed consisting of a framework of composite material with a basis of carbon or glass fibers, for example Kevlar, impregnated with resin.

Prostheses made from composite material allow a suppleness to be achieved without notable dissipation of energy, in such a way that the prosthesis restores the energy which allowed it to bend, when the need to do so ceases.

In fact, unlike prostheses made of thermo-plastic material, the suppleness of prostheses made of composite material decreases with the application of force, which is important especially when going upstairs. While a thermoplastic prosthesis would continue to bend, the composite prosthesis becomes taut and locks, then the load decreases and, when the foot leaves the step, the prosthesis restores the energy which was supplied to it, thus facilitating a restart of the body for the next step.

Prostheses of this type are described, for example, in American patents nos 4,645,509 and 4,959,073, in French patent applications published under nos 2,612,768 and 2,626,463 and in European patent applications published under nos 0401864 and 0487852.

However, none of the prostheses mentioned above is a truly polyvalent prosthesis, i.e. suitable for both normal walking and for going upstairs. The difficulty in making a

polyvalent prosthesis lies in the different reactions which it must provoke according to the type of use required of it. It must react in certain cases like a more or less supple shock absorber and in others like a sort or spring-board. In particular, the heels of prostheses proposed up to now, when they are of simple design, are either too supple, or too hard. High performance heels, on the other hand, are of a relatively complex design. None of the foot prostheses proposed up to now allows full advantage to be taken of the favourable properties described above with regard to modern composite materials.

Summary of the Invention

The aim of this invention is to propose a foot prosthesis made of composite material allowing the disadvantages of prostheses mentioned above to be remedied.

To this effect, the invention concerns a foot prosthesis made of composite material, comprising on the one hand a heel shaped like a "C", to serve as a rear support for the prosthesis on the ground, the opening of the "C" facing the back of the prosthesis, and on the other hand, a tip consisting of a front part and a back part, the front part of the tip acting as the front support of the prosthesis on the ground, the heel being set below the rear part of the tip.

According to an embodiment, the heel can comprise an upper arm and a lower arm, both of more or less flat, parallel shape. The lower arm of the heel can be longer than its upper arm.

The tip can have an extended "S" shape, comprising a front part, a rear part and an intermediate part offering an inflection area on the curve, the front part of the tip able to have a more or less flat lower surface.

The tip and/or heel can have a plurality of layers of carbon, glass or aramid fibers.

At least one part of the fiber layers of the tip can be truncated at the front, to achieve a gradation in the thickness of the tip.

All the fiber layers of the tip and/or all the fiber layers of the heel can be respectively covered with at least one layer of woven material and then impregnated and shaped.

The prosthesis can be constructed in such a way that fixing it on the tibia is done with the help of a fixing element crossing the upper arm of the heel and the rear part of the tip and fixed to a linking device mounted on a tibia.

The prosthesis can comprise an element attached to the upper surface of the rear part of the tip and intended to serve as a basis for fixing the prosthesis to the linking element mounted on the tibia.

Brief Description of the Drawings

The following description, given as an example, refers to the drawing on which:

- figure 1 is a perspective view of the front three quarters of a diagrammatic example of a foot prosthesis according to the invention;

- figure 2 is a profile view of the prosthesis in figure 1 covered with a cosmetic layer;

- figure 3 is a parallel perspective view illustrating the design of the tip of the prosthesis in figure 1 while being made;

- figure 4 is a profile view of a diagrammatic example of a prosthesis according to the invention having a shock absorbing device of a first type;

- figure 5 is a profile view of a diagrammatic example of a prosthesis according to the invention having a shock absorbing device of a second type;

- figure 6 is a profile view of a diagrammatic example of a prosthesis according to the invention having a shock absorbing device of a third type.

Modes for Carrying Out the Invention

The framework shown in figure 1 comprises a tip 1, a heel 2 and a plate 3 serving as a basis for fixing the prosthesis to an artificial tibia. Tip 1 and heel 2 are made separately of composite material, and are then assembled with the aid of a screw 4 when fixing the prosthesis to the artificial tibia, screw 4 crossing upper arm 7 of the heel, the rear part 11 of the tip, then the basic plate 3 and screwed to a linking device, known in the art, fixed to the tibia.

As can be seen from figures 1 and 2, the profile of the tip brings to mind the shape of an elongated "S", comprising a front supporting part 10, making up the so-called tip, and a rear part 11, more or less flat, with smaller dimensions than those of the front-part, the intermediate part 13 linking the front and rear parts offering a inflection area for the curve of the tip. The front supporting part 10 of the tip offers a lower surface 12 which is significantly flat.

Tip 1 has a plurality of layers of carbon fibers, glass fibers or aramid fibers arranged lengthwise and/or widthwise according to the degree of suppleness desired. Each layer, with a thickness of the order of 0,5 millimeters, is cut to the shape of the foot. The front part of the upper layers is truncated gradually towards the top in such a way as to reduce the thickness of the tip gradually between its front end and its rear end, as shown in figure 3. The whole is then covered with one or more layers of woven material, for example, plaits

of carbon fibers or any other suitable fiber, such as glass or aramid fibers. The percentage of each kind of fiber and the direction of these fibers determine the different models of prostheses according to the weight and degree of activity of the patient. Thus for example, the percentage of glass fibers will be increased to increase the suppleness of the prosthesis or, on the other hand, the percentage of carbon fibers will be increased to reduce this suppleness. The unit obtained is then treated by the RTM moulding process (Resin Transfer Moulding), a process known in the art, in such a way as to impregnate the unit with epoxy resin by injection in a closed mould, while giving it the desired shape. The unit is then cut at the ends according to the size and shape required.

The heel 2 has a "C" shape of which opening 5 faces the back of the prosthesis. It is arranged below the rear part 11 of the tip. According to a preferential embodiment, the two arms of the C are of a flat, parallel shape, the lower arm 6 being significantly longer than the upper arm 7. The heel can be made according to the same process as the tip, the only difference being that the fiber layers all have the same surface, i.e., there is not necessarily a gradation of the thickness. A circular hole 8 intended for handling screw 4 is provided in the lower arm 6 of the heel. This hole is sited in such a way that its centre coincides with axis 9 of screw 4.

The base of fixing 3 can, for example, be machined in a plate of glass/epoxy fibers with a thickness of the order of four millimeters or moulded in glass-carbon/epoxy. It can be fixed at the upper rear end of the tip by glueing, for example using epoxy resin.

The association of the "C" shape of the heel and the "S" shape of the tip actually allow polyvalent performances of the foot prosthesis according to the invention. We must here stress the fact that the polyvalent properties derive from the structural characteristics of the prosthesis, while using only simple elements, i.e., without resorting to complex devices.

In fact, the "C" shaped he l, with its opening facing the rear, allows adequate cushioning in normal walking. This cushioning benefits fully and directly from the nature and properties of the materials used, in such a way that response to the requirement is a direct function of the requirement itself and is consequently fully suited to it, without sudden locking, or fixed abutment. On the other hand, the "S" shape of the tip, with a front part offering a flat lower surface, is especially well suited for setting the foot on the step of a staircase. The "S" shape offers a curve and a counter-curve allowing optimum restitution of the energy supplied to the prosthesis when the foot is leaning on the step. This restitution occurs in a way in two places thanks to the double curve. Furthermore, the reduction in the thickness of the tip towards the front of this allows good suppleness of the front of the foot when bending the foot. Using several preformed curves offers the advantage of allowing at the same time one bend accentuating the curve and one bend acting against the curve. According to the nature of the requirement, the distribution between the two types of bend will be different, but in all cases the result will be a harmonius reaction offering the user a new comfort. In addition, taking its design into account, the area of connection between the heel 1 and the tip 2 does not bend out of shape and there is consequently no relative movement between the heel and the tip in this area, therefore no friction, which avoids any squeaking when taking a step.

We must still insist on the gradation in thickness at the front of the tip. In fact, this gradation allows a relaunching effect to take place with an important horizontal component. In fact, this part recreates the small impulse normally given by the toes when walking. This impulse allows a relaunch of the limb, in opposition to the relaunch of the entire body which results from the median part of the tip.

The very restricted number of elements making up the prosthesis offers two immediately discernable advantages. In

the first place, it is find a simplicity in manufacture, assembly and maintenance, and in the second place, the extreme reliability of the unit. The manufacturing technique used, like the simplicity of the shapes of the elements, allows industrial production and consequently a substantial reduction in manufacturing costs. Finally, and this is without doubt the most important thing, by only putting to use a limited number of parts with simple shapes and only resorting to a manufacturing technology which is relatively simple, the prosthesis in accordance with the invention offers characteristics in use which are truly polyvalent, expressed in perfect harmony with each other, thanks specifically to the combination of simple and intimately complementary lines making full use of the performances belonging to the materials used.

The prosthesis which has been described above can be used as it is, without covering layer, as shown in figure 1, or provided with a cosmetic covering 15, as shown in figure 2. Thanks to the simplicity of shapes of its elements, the prosthesis from the invention can be very easily put on and allows the quasi-perfect reconstruction of a foot, thanks especially to the narrowness of the prosthesis at the level of the ankle. A filling foam 16 can be used in the volume delimited on the one hand by the intermediate part 13 of the tip and on the other hand by the angled part of heel 2. A filling foam can also be provided in the interior of the heel limited by its two arms 6 and 7.

In order to improve comfort still further when the heel strikes the ground, a cushioning device, which can be adjustable, can be inserted in the heel of the prosthesis in such a way as to allow progressiveness in the strike of the heel. This cushioning device can, for example, have a basic, independent supporting plate linked to the heel by a cushioning element.

According t a first embodiment, shown in figure 4, the cushioning device comprises a basic supporting plate 41 fixed under the lower arm 6 of the heel and interdependent with a cushioning cylinder 42, for example in polyurethane, mounted under the upper arm 7 of the heel.

According to a second embodiment, shown in figure 5, the cushioning device comprises a basic supporting plate 51 similar tc plate 41 and fixed in a similar fashion. Plate 51 is interdependent with a cushioning element 52 interdependent with upper arm 7 of the heel and comprising a spring 53.

According to a third embodiment, shown in figure 6, the cushioning device comprises a basic supporting plate 61 fixed under the lower arm 6 of the heel and mounted at articulation 62 at the front part of the said lower arm 6. The plate 61 acts counter to a hydraulic shock absorber 64 interdependent with lower arm 6 of the heel. This shock absorber can be adjustable by means of an adjusting device 65.

In the three cases which have just been described, a compensation foam can be used under the basic supporting plate 41, 51, 61 to compensate for irregularities in the cosmetic covering.

Claims

1. Foot prosthesis made of composite material, characterised in that it comprises on the one hand a heel (2) in the shape of a "C", intended to serve as a rear support for the prosthesis on the ground, the opening (5) of the "C" facing the back of the prosthesis, and on the other hand a tip comprising a front part (10) and a rear part (11), the front part (10) of the tip being intended for front support of the prosthesis against the ground, the heel (2) being arranged under the back part (11) of the tip.

2. Foot prosthesis according to claim 1, characterised in that the heel (2) comprises an upper arm (7) and a lower arm (6), both of substantially flat, parallel shapes.

3. Prosthesis according to claim 2, characterised in that the lower arm (6) of the heel is longer than its upper arm (7).

4. Foot prosthesis according to one of the preceding claims, characterised in that the tip is in the shape of an elongated "S", comprising a front part (10), a back part (11) and an intermediate part (13) offering on inflection area on the curve.

5. Foot prosthesis according to claim 4, characterised in that the front part (10) of the tip comprises a substantially flat lower surface (12).

6. Foot prosthesis according to one of the preceding claims, characterised in that the tip and/or heel comprise(s) a plurality of carbon, glass or aramid fiber layers.

7. Foot prosthesis according to claim 6, characterised in that a part at least of the layers of fiber of the tip are truncated at the front, in such a way as to constitute a gradation of the thickness of the tip.

8. Foot prosthesis according to one of the claims 6 or 7, characterised in that all the layers of fiber of the tip and/or all the layers of fiber of the heel is (are) respectively covered with at least one layer of woven material then is (are) impregnated and shaped.

9. Foot prosthesis according to one of the preceding claims, characterised in that it is arranged in such a way that the fixing of the prosthesis on the tibia is done with the help of a fixing element (4) crossing the upper arm (7) of the heel and the back part (11) of the tip and fixed to a linking device mounted on a tibia.

10. Foot prosthesis according to claim 9, characterised in that it comprises an element (3) arranged on the upper surface of the back part (11) of the tip and intended to serve as a base for fixing the prosthesis on the linking element mounted on the tibia.

11. Foot prosthesis according to one of the preceding claims, characterised in that a cushioning device, which can be adjustable, is inserted in the heel of the prosthesis in such a way as to allow progression in the strike of the heel.

12. Foot prosthesis according to claim 11, characterised in that the cushioning device comprises an independent basic supporting plate linked to the heel by a cushioning element.

FIG.1

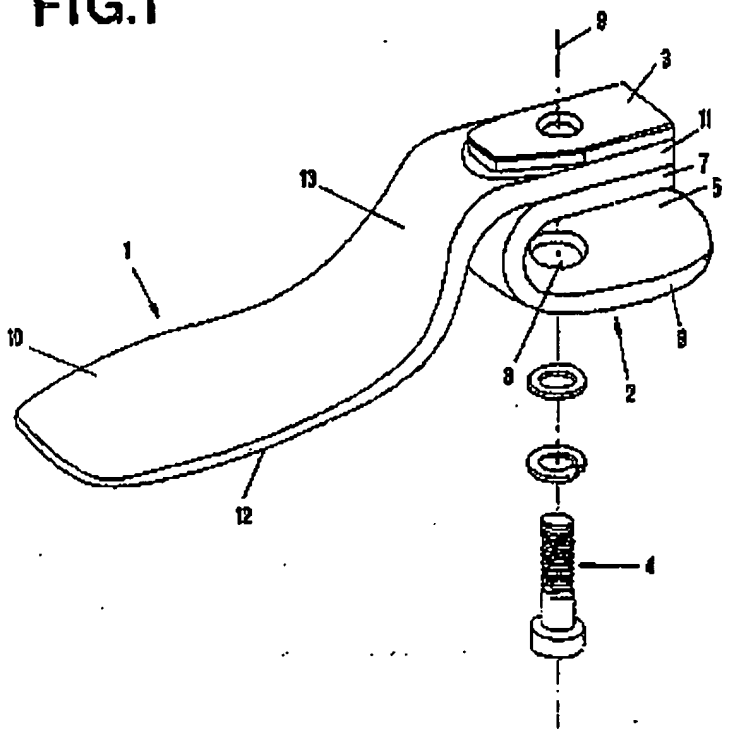
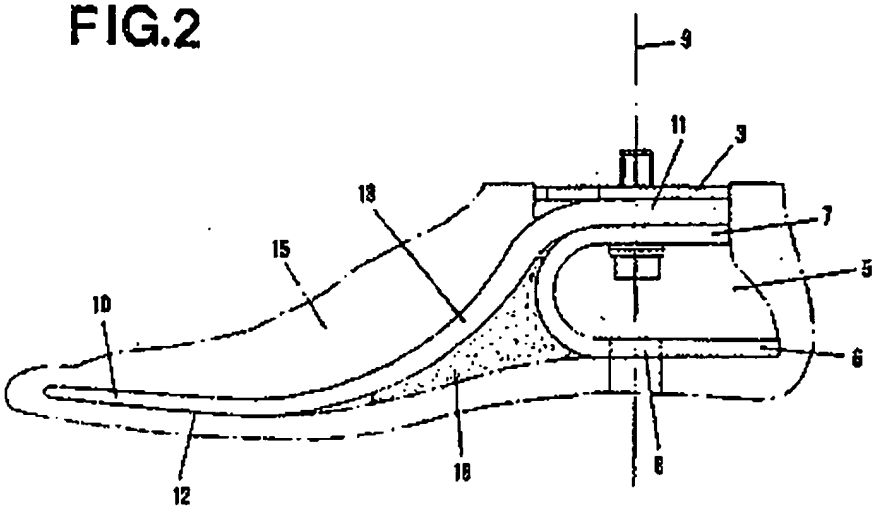


FIG.2



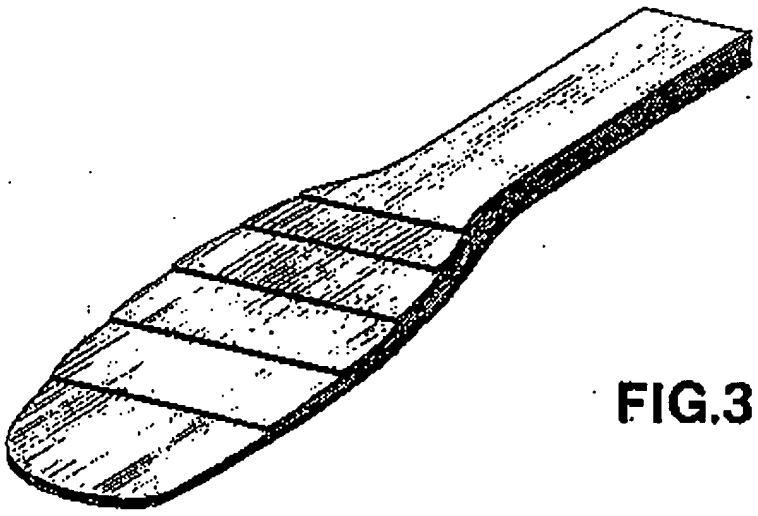


FIG.3

FIG.4

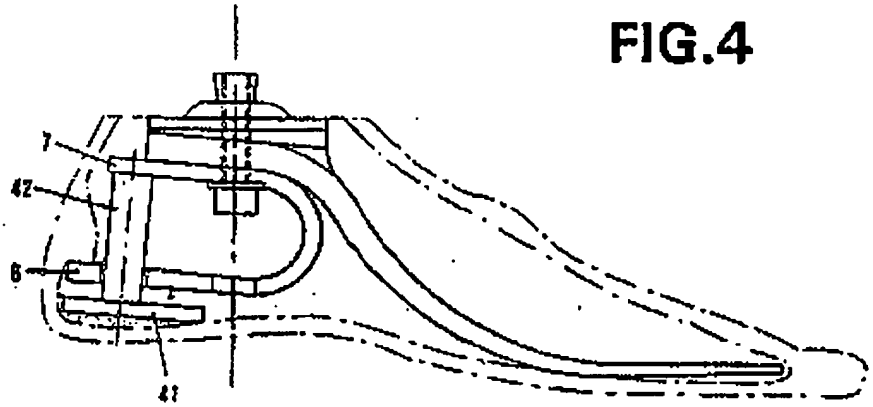


FIG.5

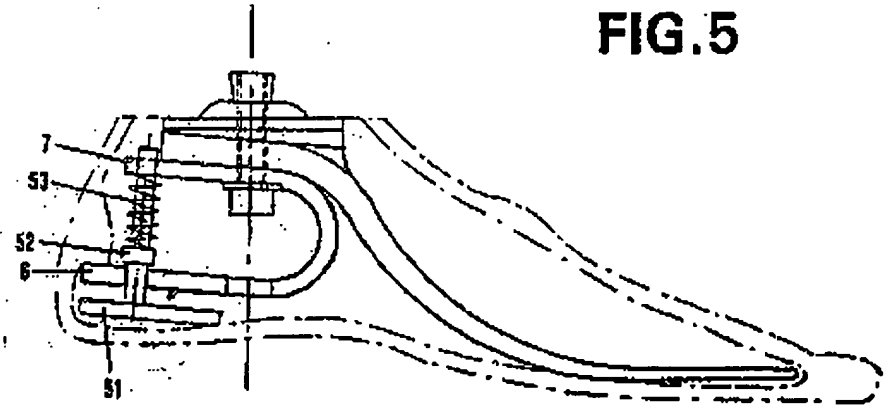


FIG.6